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ABSTRACT

This document presents data collected from all American engineering colleges for the academic year 1990-91 on minority enrollment and graduation rates by gender. The objective in analyzing the data was to determine what gender-specific engineering education issues should be considered in pursuing the goal of increased minority participation. To measure the participation level in engineering relative to population distribution, a new parameter, the Engineering Participation Factor (EPF), was developed that establishes the ratio of the percent of engineering graduates to the percent of college-age population for any particular group. EPF data are presented for: (1) minority and nonminority enrollment and graduates by gender; (2) minority freshman engineering enrollment by ethnicity and gender; (3) total minority engineering enrollment by ethnicity and gender; and (4) minority engineering graduates by ethnicity and gender. Analysis of the data indicated that minority women face two dimensional obstacles with respect to access to engineering careers, one associated with their status as minorities and the other with their status as women. The study concluded that minority women constitute the most under-represented group in the field of engineering. Implications of the data with respect to reducing barriers for minority women in engineering, increasing retention rates, and the relatively larger proportion of minority women in engineering compared to nonminority women are discussed. (MDH)

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Research Letter

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The Gender Gap in Minority Engineering Education

George Campbell Jr.

Highlights

- In 1991, 26.1 percent of the minority engineering graduates but only 14.8 percent of the nonminority graduates were women.
- Women comprised 34.0 percent of the African American, 18.2 percent of the Hispanic and 18.5 percent of the American Indian engineering graduates.
- Of the 1,196 minority women engineering graduates in 1991, 65.5 percent were African American, 32.3 percent were Hispanic and 2.3 percent were American Indian. (See note, page 6.)
- Minority women comprised 12.1 percent of all women engineering graduates. Minority males were only 6.3 percent of the graduating men. Of the total B.S. degrees in engineering awarded to both males and females, 7.2 percent went to minorities.
- Though minority women appear to fare better than their nonminority peers when measured against men in their respective groups, in the context of the total population of engineering graduates, they remain the most severely underrepresented group, constituting only 1.9 percent of the graduates and 14 percent of the college-age population.
- The proportion of minority women among engineering graduates would have to increase by a factor of 7.4 to achieve parity with respect to population distribution. The proportion of nonminority women would have to grow by a factor of 2.7.
- In relation to population distribution, minority male engineering graduates are underrepresented by a factor of 2.5 and nonminority males are overrepresented by a factor of 2.2.
- With respect to enrollment, minority women in the freshman class of 1990-91 are at 30 percent of parity while nonminority women are at 37 percent. Minority men are at 85 percent compared to 200 percent for nonminority men. If historical retention trends are maintained, however, the percentages for minorities will be halved by graduation time.

It is well established that girls growing up in our culture experience sex role socialization processes that discourage them from quantitative or scientific pursuits.[1] Throughout their educational experience, women studying mathematics, science and engineering face significantly different obstacles from those confronting men.[2] Although there's no reason to believe that minority women are immune to the impediments that limit technical career opportunities for other women, in examining the problems of access and retention in science and engineering, the literature generally treats minority and gender issues independently.[3] Given the conspicuous fact that more than half of minorities are women, analyses based on this approach are not likely to lead to optimal strategies or effective solutions to the problem of minority underrepresentation.

Introduction

This year, for the first time, the Engineering Manpower Commission, under its grant from NACME, assembled data on minority enrollment and graduation by gender. The data, collected from all American engineering colleges, covers the 1990-91 academic year.[4] Our objective in gathering and analyzing this information was to determine what gender-specific engineering education issues NACME must consider in pursuing the goal of increased minority participation.

Based on profiles of NACME scholarship recipients, we anticipated a relatively high proportion of women within the minority enrollment population. In a typical year, approximately one-third of NACME's scholarships go to women, and NACME scholars – ten to twelve percent of all minorities enrolled in engineering – represent a statistically significant sample. In what follows, we report that, indeed, women comprise a large fraction of the minority enrollment in engineering. It is, therefore, especially important to consider gender issues along with those attributable to ethnicity or race as we strive toward greater inclusion of minorities in the nation's scientific and engineering enterprise.

Graduates

In 1991, women of all population groups continued to be significantly underrepresented in engineering. However, there were substantial variations among the different populations. Women comprised 26.1 percent of the minority engineering graduates, and only 14.8 percent of the nonminority graduates (Figures 1a and 1b).[5] The individual minority populations also exhibited significant differences in the proportion of women graduates (Figures 2 and 3, Tables 1 and 4). Women comprised:

- 34.0 percent of the African American engineering graduates;

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- 18.2 percent of the Hispanic engineering graduates; and
- 18.5 percent of the American Indian engineering graduates.

In each minority group, the proportion of women was higher than that in the nonminority population by a statistically significant amount. However, it is clear that something different is happening in the African American population, with twice the proportion of women than in the other groups.

Of the 1,196 minority women graduates, 65.5 percent were African American, 32.3 percent Hispanic and 2.3 percent American Indian (Figures 3 and 4). This diverged considerably from the composition of the 3,379 minority male graduates, among whom 45.0 percent were African American, 51.5 percent Hispanic and 3.5 percent American Indian (Figures 3 and 5).

Examining the data from the perspective of total engineering graduates grouped by gender, 12.1 percent of the women but only 6.3 percent of the men were minorities. The disparity here is as much a function of the underrepresentation of nonminority women (or overrepresentation of nonminority men) as it is of the relatively larger participation of minority women.

It is very important to emphasize that, while minority women appear to have achieved significantly greater presence among engineering graduates than their nonminority peers when measured against males in their respective communities, in the context of the total population of engineering graduates, they remain the most severely underrepresented group. Specifically, minority women comprise only 1.9 percent of the graduates while constituting 14 percent of the college-age population.

Engineering Participation Factors

The Engineering Participation Factor (EPF), defined in the box below, provides a comparative measure of the degree of representation in the field for a given population group. EPF_g is the ratio of percent of engineering graduates to percent of college-age population. An EPF of 1 reflects perfect parity with respect to population density. For EPF < 1, the inverse (1/EPF) is the Underrepresentation Factor (URF), the multiplicative factor by which the proportion of the group must increase to achieve parity. Table 5 shows EPF_g and URF_g for minority and nonminority men and women. With an EPF_g of 0.136, the proportion of minority women graduates would have to increase by a factor of 7.4 (URF_g = 7.4) to achieve parity. Similarly the proportion of nonminority women would have to increase by a factor of 2.7. Minority males are underrepresented by a factor of 2.5 and nonminority male graduates are overrepresented by a factor of 2.2.

We can disaggregate population data to examine the participation of individual minority groups. Unfortunately, with available census data, we are only able to calculate accurate EPF and URF for the African American and Hispanic populations (Table 6). The data indicate that neither of these groups

Engineering Participation Factor

To measure the level of participation in engineering relative to population distribution and to facilitate comparison of different groups, we established a new parameter, the Engineering Participation Factor (EPF). The EPF for a particular group in the graduating class, EPF_g, is the ratio of percent of engineering graduates to percent of college-age population. An EPF of 1 implies exact parity, i.e., participation in engineering commensurate with proportion of the population. When EPF is less than 1, the inverse (1/EPF) is the Underrepresentation Factor (URF). An EPF greater than 1 is a direct measure of overrepresentation.

For example, minority women were 1.9 percent of the 1990-91 engineering graduates and 14 percent of the college-age population, yielding an EPF_g of 0.136. To achieve parity, i.e., EPF_g=1, the proportion of women would have to increase by a factor of 7.4, the URF_g. On the other hand, for nonminority men – 79.1 percent of the graduates and 36 percent of the college-age population – EPF_g=2.2. This means that nonminority men are overrepresented by a factor of 2.2.

EPF can also be defined with respect to enrollment, e.g., freshman enrollment, denoted EPF_f, or total enrollment, EPF_t. These are percent of freshman and total enrollment, respectively, divided by percent of college-age population for a given group.

The EPF concept has potentially broad applications. For example, it could be calculated on a regional basis, or a similar parameter could be defined to assess participation in engineering prerequisites for a collection of high schools. This would enable universities to set reasonable recruitment goals.

The concept is also useful in assessing the feasibility of numerical goals for minority graduates that have already been proposed by organizations such as the National Science Foundation and other government agencies, as well as by individual universities. Achieving some of these goals, e.g., five times the current production by the end of the decade, demands participation of minority males well beyond parity and significant increases in the participation of minority women, along with substantial improvements in retention. Enrollment data discussed in the text suggest that such dramatic progress is not likely to happen in the next five years.

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Table 1.
1990-91 Minority and Nonminority Enrollment and Graduates by Gender

	Percent of College-age Population	Freshman Enrollment		Total Enrollment		Graduates	
		Number	Percent	Number	Percent	Number	Percent
Women							
Nonminority	37	12,860	13.7	45,846	13.7	8,685	13.7
Minority	14	3,975	4.2	10,120	3.0	1,196	1.9
Subtotal	51	16,835	18.0	55,966	16.7	9,881	15.6
Men							
Nonminority	36	66,567	71.0	250,962	74.9	50,186	79.1
Minority	13	10,303	11.0	28,174	8.4	3,379	5.3
Subtotal	49	76,870	82.0	279,136	83.3	53,565	84.4
Total	**100**	**93,705**	**100.0**	**335,102**	**100.0**	**63,446**	**100.0**

is within a factor of two of parity. Hispanic men are closer to parity than African American men, and African American women are closer than Hispanic women. As expected, women in both cases are far more severely underrepresented with respect to their presence in the population. The proportion of Hispanic women among the total engineering graduates must be increased by a factor of 8.5 to achieve parity, while African American women are underrepresented by a factor of 6.3.

We can also calculate EPF based on college enrollment rather than on college-age population. Because of the overrepresentation of women pursuing higher education, the level of underrepresentation in engineering among college-going women for each group considered here is even greater than that based on population distribution.[6]

Freshman Enrollment

Nonminority women comprised 13.7 percent of the 1990-91 freshman enrollment. This is identical to the percentage of nonminority women in the graduating class of 1991. Minority women made up 4.2 percent of the 1990-91 freshmen – more than twice the 1.9 percent minority women seen in the graduating class of 1991 (Table 1).

The pattern of freshman enrollment within the minority population almost exactly mirrors the pattern seen among graduates. Minority women were 27.8 percent of the minority freshmen, and by far the largest number of minority women freshmen, almost 70 percent of the total, were African American. Within the African American student population, women accounted for 33.1 percent of the freshmen.

However, the patterns exhibited are very different for freshmen and for graduates when we include the nonminority populations. The EPF_f is more than double the EPF_g for both minority women and men (Table 5). This means that, relative to population density, the representation of minorities of both genders in the freshman class was more than twice as high as it was in the graduating class of 1991.

It is noteworthy that minority males are approaching parity in the freshman class. Calculating EPF_f by ethnicity and gender, we find that the African American and Hispanic male freshman populations individually are also very close to parity, while first-year African American and Hispanic women are underrepresented by factors of 2.6 and 4.5, respectively (Table 6).

The Impact of Attrition

As observed in the previous section, the percentage of nonminority women in the freshman class of 1990-91 was the same as that of the 1990-91 graduating class. Because of the slightly higher attrition of women, this portends a decline in the proportion of nonminority women in the graduating class of 1994 (or 1995, assuming a five year average time to graduate). The decline may be tempered somewhat by the fact that 1990-91 freshmen included a record number of minorities, who in the past have had the highest attrition rates.[7] That is, the percentage of nonminority women may hold up; nevertheless, in real terms, we can expect little progress and even some regression in their participation in engineering over the next four or five years.

Attrition has a more devastating impact on minorities. The freshman participation level of minorities, both men and women, was twice that in the graduating class. However, minority attrition has historically been twice that of nonminorities.[8] If this attrition pattern persists, we can expect virtually no improvement in the proportion of minorities in the graduating class of 1994 (or 1995). Unfortunately, little information is available on the attrition of minorities by gender. It's important to observe, however, that if the retention of minority males merely keeps pace with that of the nonminority population, they will be entering the engineering profession in 1994 (or 1995) in numbers almost commensurate (85 percent of parity) with their distribution in the population.

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Figure 1(a):
1991 Minority Engineering Graduates by Gender

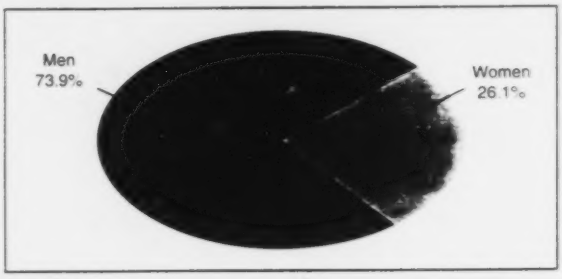
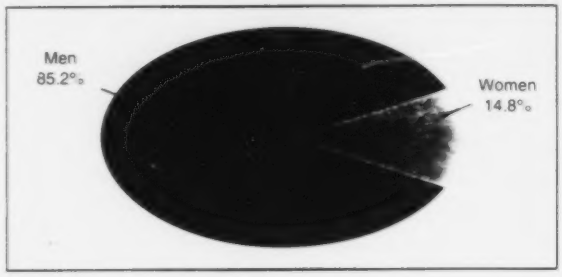


Figure 1(b):
1991 Nonminority Engineering Graduates by Gender



We also know that among the individual minority groups, African Americans have the highest attrition rates.[3] Thus, although the high EPF_f in 1990-91 reflects genuine gains in freshman enrollment for this group, it will not yield a significantly higher proportion of graduating engineers in four to five years unless retention is dramatically improved.

Total Enrollment

Because total enrollment is akin to an average of the freshman and graduation data, the patterns are very similar to those described above. The data are consistent with a higher proportion of minorities in the freshman year and a steady decline in subsequent years, reflecting higher attrition rates among minorities (Tables 3, 5 and 6).

Conclusions

The new data on minority engineering graduates and enrollment by gender support the generally recognized principle that minority women face two dimensional obstacles with respect to access to engineering careers – one associated with their status as minorities and the other with their status as women. As a consequence minority women, by a very large margin, are the most underrepresented group in the field. Relative to population distribution, i.e., $EPF_g = 0.136$, they participate at just over one-third the rate of nonminority women ($EPF_g = 0.370$), one-third the rate of minority men ($EPF_g = 0.408$) and 6 percent of the rate of nonminority men ($EPF_g = 2.2$).

These observations suggest that attention needs to be paid to developing strong programs aimed at reducing the barriers for minority women in engineering education. It has been suggested that, in general, minority-focused programs tend to serve minority women more effectively than programs designed for the general population of women.[4] The accuracy of this perspective, as well as programming implications, needs to be explored.

The overall enrollment data, dampened by retention rates, indicate that we can expect very little progress, and perhaps even some regression, in the proportion of women from all ethnic groups entering the engineering profession over the next four to five years. Thus, once again, a familiar theme emerges from a study of issues in minority engineering education – the importance of retention.

EPF calculations for the freshman class of 1990-91 showed that minority women were enrolled at 30 percent of parity and minority men at 85 percent. However, because the minority retention rate is half that of nonminorities, we can expect EPF to be reduced by half as minority students progress from freshmen to graduates. This is consistent with the observation that, in the 1991 graduating class, the minority women and men were only at 14 percent and 41 percent of parity, respectively.

For the near-parity minority male freshmen, one interpretation of the EPF_f results is that we're doing an adequate job on the recruitment or access end. Again, where the process fails is in engineering school retention. Of course, in the nonminority population, males are significantly overrepresented relative to their distribution in the population. From this perspective, the number of minority males in the freshman class is far from parity.

EPF calculations also suggest that national goals for the 1990s which include a fivefold increase in minority participation in engineering are extraordinarily ambitious. Achieving them would require enrollments much greater than parity for minority men and revolutionary growth in participation of minority women, along with dramatic improvements in retention; and change would have to begin immediately.

The fine structure present in the statistics on women yields some intriguing and often anomalous results. The fraction of women among minority engineering students and graduates is significantly larger than the fraction of women among nonminority students

and graduates. This proportionally larger participation of minority women, relative to minority men, is most pronounced in the African American population, where one-third of the enrollment and one-third of the graduates are women.

The higher than average proportion of engineering degrees received by minority women is in consonance with the broader pattern of college participation for minorities. In 1990, the latest year for which overall statistics are available, the total number of bachelor's degrees awarded to women exceeded the number awarded to men by 14 percent. However, bachelor's degrees awarded to African American, American Indian and Hispanic women outnumbered those awarded to men from the same groups by 62, 32 and 20 percent, respectively.[11] Each minority group had a substantially higher than average proportion of women, and again, African Americans exhibited the most skewed distribution. Considering the huge gap between female and male bachelor's degrees that went to African Americans, it's not surprising that a large proportion of the engineering graduates in the group were women.

This large proportion of minority women graduates relative to men also has a subtle but important long-term implication for work force diversity. The overall representation of minorities in engineering for a given cohort at the entry level, independent of gender, can only be maintained over time if the retention of women is improved relative to men. That is, employers truly committed to technical work force diversity must successfully retain minority women in technical career paths.

A compelling set of questions that emerges from the data centers on identifying what characteristics of the minority communities encourage a larger proportion of women, especially African Americans, to pursue college educations and, in particular, engineering degrees. Is this simply a reflection of greater repression of

Table 2.
1990-91 Minority Freshman Engineering Enrollment by Ethnicity and Gender

	Freshman Enrollment	Percent of Group	Percent of Total Minority
African American			
Women	2,768	33.1	19.4
Men	5,602	66.9	39.2
Subtotal	8,370	100.0	58.6
American Indian			
Women	132	25.1	0.9
Men	394	74.9	2.8
Subtotal	526	100.0	3.7
Hispanic			
Women	1,075	20.0	7.5
Men	4,307	80.0	30.2
Subtotal	5,382	100.0	37.7
Total Minority	**14,278**	**NA**	**100.0**

Table 3.
1990-91 Total Minority Engineering Enrollment by Ethnicity and Gender

	Total Enrollment	Percent of Group	Percent of Total Minority
African American			
Women	6,806	32.6	17.8
Men	14,103	67.4	36.8
Subtotal	20,909	100.0	54.6
American Indian			
Women	324	22.1	0.8
Men	1,144	77.9	3.0
Subtotal	1,468	100.0	3.8
Hispanic			
Women	2,990	18.8	7.8
Men	12,927	81.2	33.8
Subtotal	15,917	100.0	41.6
Total Minority	**38,294**	**NA**	**100.0**

Table 4.
1990-91 Minority Engineering Graduates by Ethnicity and Gender

	Graduates	Percent of Group	Percent of Total Minority
African American			
Women	783	34.0	17.1
Men	1,521	66.0	33.2
Subtotal	2,304	100.0	50.4
American Indian			
Women	27	18.5	0.6
Men	119	81.5	2.6
Subtotal	146	100.0	3.2
Hispanic			
Women	386	18.2	8.4
Men	1,739	81.8	38.0
Subtotal	2,125	100.0	46.4
Total Minority	**4,575**	**NA**	**100.0**

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Table 5.
1990-91 Engineering Participation Factors (EPF) and Underrepresentation Factors (URF) of Minorities and Nonminorities by Gender

	Freshman Enrollment		Total Enrollment		Graduates	
	EPF	URF	EPF	URF	EPF	URF
Women						
Nonminority	0.370	2.7	0.370	2.7	0.370	2.7
Minority	0.300	3.3	0.214	4.7	0.136	7.4
Subtotal	0.353	2.8	0.327	3.1	0.306	3.3
Men						
Nonminority	1.972	[2.0]	2.081	[2.1]	2.197	[2.2]
Minority	0.846	1.2	0.646	1.5	0.408	2.5
Subtotal	1.673	[1.7]	1.700	[1.7]	1.722	[1.7]

[ ] Overrepresentation

Table 6.
1990-91 Engineering Participation Factors (EPF) and Underrepresentation Factors (URF) of African Americans and Hispanics by Ethnicity and Gender

	Freshman Enrollment		Total Enrollment		Graduates	
	EPF	URF	EPF	URF	EPF	URF
African Americans						
Women	0.382	2.6	0.262	3.8	0.159	6.3
Men	0.860	1.2	0.606	1.7	0.343	2.9
Aggregate	0.608	1.6	0.425	2.4	0.247	4.0
Hispanics						
Women	0.220	4.5	0.172	5.8	0.117	8.5
Men	0.811	1.2	0.681	1.5	0.483	2.1
Aggregate	0.529	1.9	0.437	2.3	0.308	3.2

minority males? What impact has the national minority engineering effort had? It's tempting to interpret the trend in terms of the dynamics of the minority male population, e.g., the large fraction of African American and Hispanic males enmeshed in the criminal justice system or the high incidence of mental disorders, suicide, gang behavior, depression, etc. among college-age minority males.[2] However, this approach breaks down in light of the near-parity representation of minority male freshmen. Other possible explanations might relate to family structure, culture or historical legacy. A deeper understanding is critically important in developing effective program strategies for the future. Hopefully the data reported here will be useful in formulating a research agenda to probe these gender-specific issues.

Note
Due to rounding, summands may not always add to the totals.

Acknowledgement
I wish to thank members of the NACME staff, Lea Williams, Aileen Walter and Frank Wells, for their thoughtful review of the paper. I especially thank Lynn Miyazaki, who meticulously checked the data and calculations, and Ronni Denes, who provided expert editorial counsel.

Footnotes
1. See for example, Committee on Women in Science and Engineering, Office of Scientific and Engineering Personnel, National Research Council, *Women in Science and Engineering: Increasing Their Numbers in the 1990s*, National Academy Press, Washington, DC, 1991, p. 47.

2. The Wellesley College Center for Research on Women, The AAUW Report, *How Schools Shortchange Girls*, The American Association of University Women Educational Foundation, 1992, pp. 28-32.

3. Throughout the paper "minority" refers to the minority groups under-

Figure 2:
1990-91 Percent of Women Engineering Graduates in Each Population Group

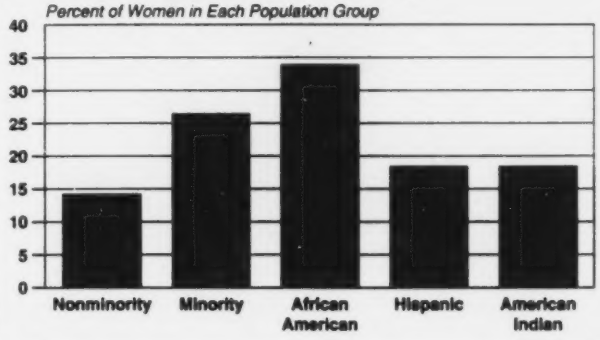


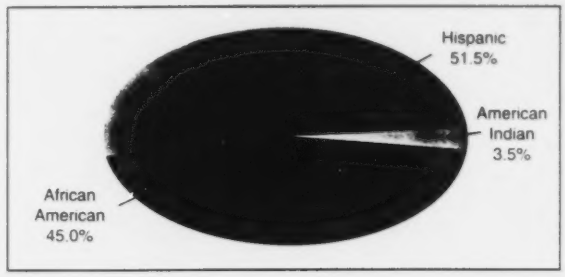
Figure 3:
1991 Minority Engineering Graduates by Ethnicity and Gender

See note, page 8.

Figure 4:
1991 Minority Women Graduates by Ethnicity

See note, page 8.

Figure 5:
1991 Minority Men Graduates by Ethnicity



represented in engineering, i.e., African Americans, American Indians and Hispanics. "Nonminority" refers to all other groups combined.

4. Gender for a small fraction of the populations of interest, e.g. 0.001 for all engineering graduates, is not known. We apportion these unknowns to the male and female populations in the same ratio as that of the known population. This yields total enrollment and graduation data that is consistent with data published elsewhere.

5. All enrollment and graduation information in this report excludes the University of Puerto Rico (UPR). The proportion of women graduates from UPR is slightly higher than the proportion of Hispanic graduates from all other schools. Including the UPR, for example, would change the percentage of women among Hispanic graduates from 18.2% to 20.1%.

6. Separating the groups that make up the nonminority and minority populations, we find that male college graduates or enrollments outnumber women only among Asian Americans.

7. G. Campbell Jr. et al, *NACME Research Letter*, Vol. 2, No. 2, December, 1991.

8. G. Campbell Jr., et al., op. cit.

9. G. Campbell Jr., et al., op. cit.

10. This suggestion was made and supported anecdotally at the national conference: *Science and Engineering Programs: On Target for Women?* Committee on Women in Science and Engineering, National Academy of Sciences/ National Academy of Engineering, Irvine, CA, November 4-5, 1991.

11. D.J. Carter and R. Wilson, *Tenth Annual Status Report, 1991: Minorities in Higher Education, American Council on Higher Education*, 1992, p. 48.

12. R. Majors and J.M. Billson, *Cool Pose: The Dilemmas of Black Manhood in America*, Lexington Books, New York, 1992, pp.11-26.

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